Measuring Booster Beam Loss with Scintillator Detectors

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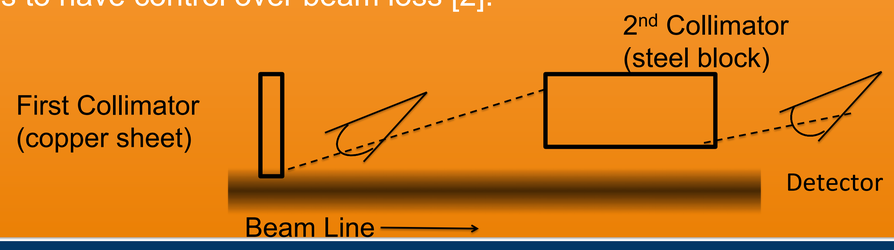
Accelerator Losses

The Booster supplies beam to the main injector, miniBooNE, NuMI, and MINOS experiments. Because of its importance, the Booster is the complex's bottleneck. The collimation system has never worked as designed [1]. The purpose of this research is to study the two-stage collimation system, monitor beam-loss, and to optimize the collimators to have control over beam loss [2].



Collimator Instrumentation

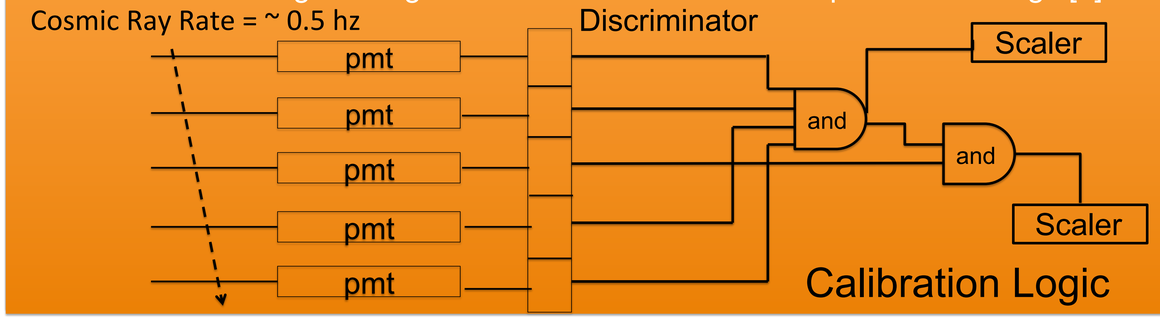
Scintillator detectors will be placed down stream of each collimator to measure particle interactions with the collimators. When the rate of RF bucket losses is found, collimators may be adjusted to control beam loss more adequately.

Things to Consider…

- The RF buckets occur at a frequency between 38–52 MHz (about every 20 ns), so signals must begin and end within this time constraint.
- Residual radiation from the beam and activated materials stand as an obstacle for these detectors. G-10 shells protect the modules from this.
- All detectors must be able to produce similar signals for similar inputs [3].

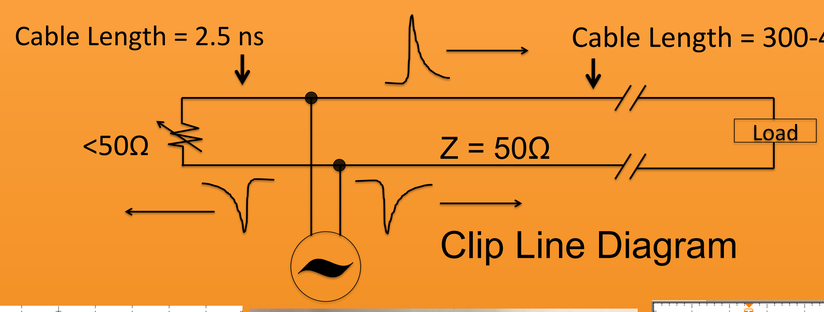
Detector Calibration

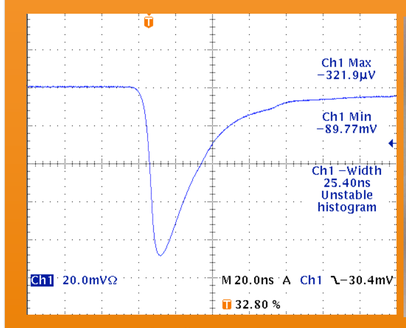
- Efficiency vs. High Voltage: How sensitive the detector is to minimum ionizing particles
- Pulse Height vs. High Voltage: Pulse shapes must be similar.
- Noise Rate vs. High Voltage: To reduce chances of false-positive readings [3]



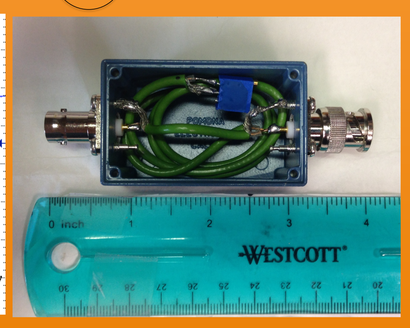
Pulse Shaping

Each detector has been equipped with a Pomona box designed to take advantage of the principle of superposition and properties of impedance mismatching. Each signal will split, reflect, and destruct the original wave. The delay cable averages a length of 2.5 ns.

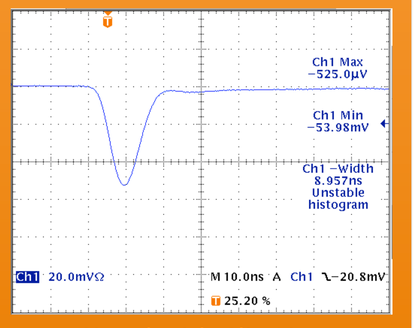




Signal before Clip Line



Clip Line



Signal with Clip Line

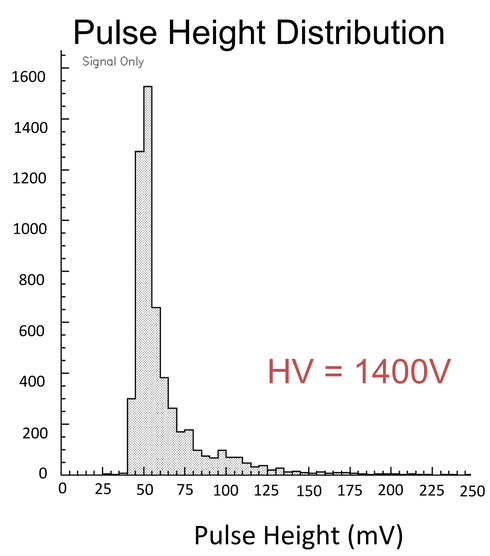
Conclusions

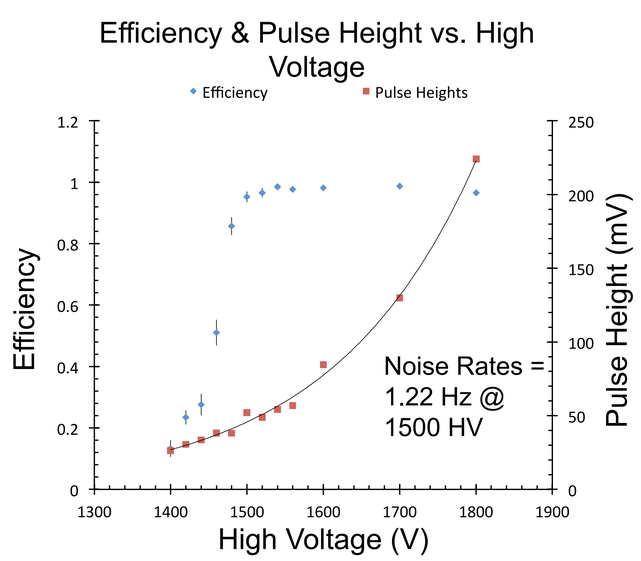
- With the new modules installed, the collimation system can finally be optimized the way they were designed to be.
- With each adjustment, the rate at which RF buckets lose beam will increase or decrease, and further fine tuning can occur [4].
- With the collimators adjusted, beam loss will occur in appropriate areas, meaning sensitive instruments will no longer be compromised.
- This will also result in less random beam loss, meaning more data for all of the projects that the Booster provides beam for.

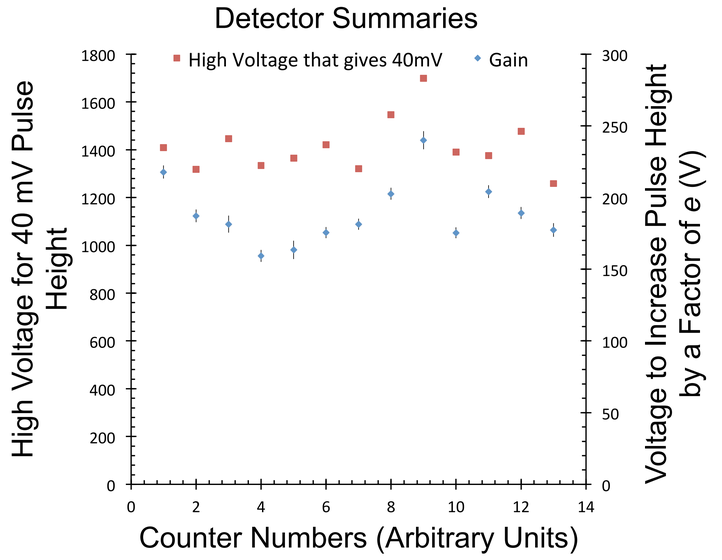
References

1. R. Tesarek, "E-Sector Collimators: What are They Doing?" Talk at Crystal Collimation Meeting, Fermilab, September 17, 2008.
2. R. Tesarek, "Instrumentation to Detect Crystal Channelling: Status + Plans" Talk at Crystal Collumation Meeting, Fermilab, August 7, 2008.
3. R. Tesarek, "Fast Booster Loss Monitors." Fermilab Accelerator Division DocDB – 4797, April 9, 2015.
4. R. Tesarek, "Oct. 10 End of Store Studies: What Did I Learn?" Talk at Crystal Collimation Meeting, Fermilab, October 17, 2008.

Calibration Results







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